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COMPLETE SPECIFICATION.

Improvements in or relating to the Recovery of Sulphur from Gases containing Hydrogen Sulphide.

We, THE GAS COUNCIL, a British Body Corporate, of 1 Grosvenor Place, London, S.W.1, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention is for improvements in or relating to the recovery of sulphur from gases and has particular reference to the recovery of sulphur from a hydrogen sulphide-containing gas.

In our Specification No. 722,038 we have disclosed a two-stage process for the recovery of sulphur from hydrogen sulphide-containing gases which has advantages over the known Claus Kiln process. The disadvantages of the process of Specification No. 722,038 are that it involves the provision of two or more second-stage reactors with changeover valves for periodic reversal in a system subject to corrosion and blockage, and that there is a tendency for loss of activity of the catalyst for the second stage, associated with a reduction of its surface area and an increase in its sulphate content.

These disadvantages would be minimised if the load on the second stage were reduced. We have therefore considered the means necessary to improve the degree of conversion of hydrogen sulphide to sulphur in the first catalytic stage which is a continuous process which, in effective practice, must always be conducted at temperatures above the dewpoint for sulphur. The equilibrium in the Claus process is such that formation of sulphur can be more nearly complete the lower the temperature, and the reaction is strongly exothermic. The highest yields of sulphur from a continuously operated

first-stage are therefore achieved by close temperature control by removal of the exothermic heat of reaction to permit operation at an outlet temperature nearly as low as the dewpoint for sulphur.

We have now found that such close temperature control combined with much reduced dewpoint temperatures for sulphur and, in consequence, much increased sulphur yields may be effected by recirculation of gas from the outlet of the sulphur condenser to those zones where the exothermic reaction tends to raise the temperature too much; such addition of cool gases is termed "quench cooling."

A convenient method of recirculating the cooling gas into the zones of exothermic reaction is to employ for the first catalytic stage a reactor containing two or more layers of catalyst and to introduce the gas from the outlet of the sulphur condenser in the gas spaces between the layers.

One particular advantage of the method of quench cooling of a reactor containing two or more layers of catalyst, is that a high inlet temperature and a low outlet temperature may be combined in the single reactor for an exothermic reaction. In the production of sulphur from hydrogen sulphide containing gases containing also compounds of carbon, carbon oxysulphide is produced in the primary combustion and this can be effectively converted into sulphur in the first catalytic stage only if the inlet temperature of the reactor is fairly high, e.g. 300° to 400° C., whereas a much lower temperature is needed at the reactor outlet to ensure that the reaction between hydrogen sulphide and sulphur dioxide is sufficiently complete to give a high overall yield of sulphur.

The proposed method of recirculation may be compared with straightforward dilution as a means of lowering the dewpoint for sulphur. It has the disadvantage that one of the reaction products, viz., water vapour, is maintained at a high concentration. The advantage is that the volume of stack gases is not increased. At equal water vapour concentrations and sulphur dewpoints the minimum concentration of hydrogen sulphide and sulphur dioxide in the stack gas would be the same; high overall conversions to sulphur therefore depend on keeping the stack gas volume as low as possible. This result of the recirculation method far outweighs the disadvantage of high water-vapour concentration.

The following table shows the effect of recirculation of gases from the outlet of the sulphur condenser:—

Recirculation.	Dewpoint for maximum yield of sulphur.	Maximum yield.
0 vols.	278° C.	93.6%
1 vols.	250° C.	94.9%
2 vols.	238° C.	96.7%
3 vols.	228° C.	97.2%
5 vols.	214° C.	97.9%
7 vols.	208° C.	98.3%
11 vols.	196° C.	98.6%

These figures relate to a system in which the parent hydrogen sulphide gases contained 68.5% of hydrogen sulphide by volume, wet basis, and in which the process gases at the outlet of the first catalytic stage contain 26% to 27% by volume of water vapour.

Recirculation involves the division of the gases leaving the sulphur condenser into waste gases and recirculation gases. The quantity of waste gases may be designated "one volume." In the table and throughout the Specification the quantities of recirculation gases have been expressed as multiples of the waste-gas volume.

In the table the yield of sulphur at the outlet of the first catalytic stage has been expressed as a percentage of the sulphur content of the parent hydrogen sulphide gases.

For each extent of recirculation the yield is a maximum when the temperature at the outlet of the first catalytic stage is controlled closely above the sulphur dewpoint shown in the central column of the table.

The amount of recirculation permissible is limited by the exothermic heat to be removed:—

1. To cool the first stage reactor only, assuming an entry temperature of 350° C. to ensure destruction of any carbon oxysulphide present, not more than 1½ volumes may be recirculated. The minimum

reaction temperature would be about 244° C. and the conversion could not exceed about 96%.

2. To cool the gases from the hydrogen sulphide combustion to reaction temperature and to cool the first-stage reactor, as much as 11 volumes could be recirculated. The maximum conversion would be 98.6% and the lowest reaction temperature just below 200° C. There would be no indirect cooler such as a waste-heat boiler.

Recirculation tends to increase the size and capital cost of those units carrying the increased volume of gas; it must therefore be applied only to the extent that it gives a substantial improvement in the conversion or other marked advantages.

With 1½ volumes recirculated to control the first stage reaction it should be possible to attain 95% conversion, whereas 90% would be the practicable limit in a single catalytic reactor without either recirculation or some more expensive method of cooling the gases uniformly. This form of recirculation control seems to give the most favourable conditions for a first-stage reactor in a two stage system with sulphur condensation in the catalyst for the second stage.

The greatest advantage that can result from the recirculation method is the achievement of yields or percentage conversions, in the first catalytic stage, that are so high that no discontinuous second stage is required. Yields of about 97% are, in this country, sufficient if the hydrogen sulphide content of the waste gas is destroyed, for example, by oxidation to sulphur dioxide by the process claimed in our co-pending Application No. 10,746/54 (Serial No. 769,996). By this process, and indeed by other processes requiring higher temperatures, the hydrogen sulphide content of the gases vented to the atmosphere may be reduced below one part per million by volume.

Conversions of about 97% in a continuous process, with an oxidation stage for the waste hydrogen sulphide, have been achieved in an existing plant for the recovery of sulphur from hydrogen sulphide-containing gases comprising a hydrogen sulphide burner, waste-heat boiler, sulphur condenser, reheater, first-stage reactor, second sulphur condenser, reheater, second-stage reactor, final sulphur condenser, addition of hot burner gases and excess air, final catalytic reactor for oxidation of waste hydrogen sulphide to sulphur dioxide, and tall stack.

By application of the recirculation method we have found a continuous process capable of achieving the same result with a single reactor and a single sulphur

condenser, no waste heat boiler or any source of external heat being required.

According to the present invention, there is provided a continuous process for the recovery of sulphur from a hydrogen sulphide-containing gas which process comprises burning the gas in a combustion chamber in the presence of a controlled amount of air, partially cooling the resulting gaseous mixture and passing it through a single catalytic reactor to bring about the conversion of hydrogen sulphide and sulphur dioxide to sulphur and thereafter condensing the sulphur, the catalytic reactor containing two or more layers of catalyst between which substantially sulphur-free process gas from the outlet of the sulphur condenser is recycled to control the temperature of the gas leaving the reactor at a temperature above but approximately to the sulphur dewpoint, for example, not more than 20° C. above the dewpoint.

In a preferred form of the invention, sulphur-free process gas is also recycled for addition to the gases leaving the combustion chamber thereby effecting part of the duty of cooling the combustion gases and further lowering the dewpoint for sulphur at the outlet of the reactor.

Preferably the present invention is employed in the treatment of gases containing not less than 50% of hydrogen sulphide, and in such a manner that at least 96% conversion of hydrogen sulphide to sulphur is obtained.

Following is a description by way of example and with reference to the drawing accompanying the Provisional Specification of a method embodying the present invention.

In the drawing:

The single Figure is a flow sheet indicating the several steps in the treatment of a gaseous mixture containing hydrogen sulphide.

Referring to the drawing, air at a flow rate of about 13,400 cu. ft. per hour (cu. ft. are standard cu. ft. corrected to 60° F., and 30" Hg., saturated) is passed through a filter 11 and fed by means of a blower 12 to the burner of a combustion chamber 13 where it is burnt with about 5,850 cu. ft. per hour of gas having a composition by volume on the wet basis of

Hydrogen sulphide	68.5%
Hydrogen cyanide	10.3%
Carbon dioxide	13.9%
Nitrogen	5.1%
Water vapour	2.2%

The temperature of the combustion chamber is 1100° C.

The combustion gases are cooled to

approximately 550° C. by the primary addition of quench gas at a temperature of 125° C. the volume of quench gas relative to that of waste gas being about 14:1. The exact proportion of combustion gases to quench gas is controlled by means of an automatic valve operated by a temperature control unit 14 which controls the temperature of the gases entering the heat exchanger 15. The combustion gases are then further cooled in the heat exchanger 15 which also raises a mixture of waste gas and secondary air to the temperature required for the final oxidation of the hydrogen sulphide in the waste gas.

The combustion gases then pass to a catalytic reactor 16 containing three layers 17, 18 and 19 of activated alumina catalyst. The inlet temperature of the gases is 350° C. and is controlled by a temperature control unit 20 operating a valve in the secondary air conduit. Quench gas is added at 21 and 22 between the layers of catalyst, the volume of each addition of quench gas relative to that of waste gas being about 14:1. The quench gas cools and dilutes the reaction gas, so that the outlet temperature is 222° C. The dewpoint for sulphur at the outlet of the reactor is about 214° C. The operation of the reactor with an outlet temperature close to the sulphur dewpoint is ensured by thermostatic control by control unit 23 of the combined volumes of the quench gases entering at 21 and 22.

The hydrogen sulphide-sulphur dioxide reaction on activated alumina is extremely fast at these temperatures, and a close approach to equilibrium is reached at high throughputs. Thus the total volume of catalyst may be as little as 10 cu. ft. for each ton per day of sulphur produced.

The gases leaving the reactor are next passed into an air cooled sulphur condenser 24 from the bottom of which liquid sulphur flows under gravity through a seal at the rate 3.44 tons per day. The sulphur condenser is larger than that required in the absence of recirculation because the total cooling load is approximately doubled. However, it is still only a small atmospheric condenser.

The total volume of gas leaving the sulphur condenser is about 5½ volumes at a temperature of 125° C. of which 1 volume is passed to waste and about 4½ volumes are recirculated. The waste gas is mixed with about 19,000 cu. ft. per hour (1.1 volumes) of secondary air (from the filter 25 and blower 26) in the heat exchanger 15 and is passed into a catalyst vessel 27 containing about 20 cu. ft. of a catalyst of nickel sulphate supported on granules of activated alumina. The waste hydrogen sulphide is oxidised to sulphur dioxide on the nickel sulphate catalyst and the treated

gases leave the vessel 27 at a temperature of 350° C. and then pass to the stack. The stack gases have the following characteristics:—

5	Standard volume	31,500 cu. ft. per hr.
	Wet volume	36,000 cu. ft. per hr.
	Dewpoint	52° C.
	H ₂ S concentration	
10	by volume, wet basis	About 1 part per million by volume.
	SO ₂ concentration	
	by volume, wet basis	0.35%.
	Total SO ₂ emission	500 lbs. per day.

15 The recirculated gas for quench cooling is recycled by means of the blower 28 at 75,000 cu. ft. per hour at 125° C. saturated with sulphur vapour. The control of the primary air from blower 12 is maintained by an automatic analyser 29 for the hydrogen sulphide/sulphur dioxide ratio in the recycle gas. Such an analyser is described and claimed in our co-pending Application No. 14097/54 (Serial No. 769,997).

25 The temperature control on the primary quench gas serves to protect the heat exchanger material from the corrosion which would occur much more rapidly at higher temperatures. The temperature is set as low as the heat balance of the plant permits.

30 The process described above, giving 97% conversion of hydrogen sulphide to sulphur is dependent on one primary utility service only, steam, for its continued operation. The steam is used in a single common prime mover for all the gas pumps and for protective heating of the plant at all positions vulnerable to sulphur solidification. Since the supply of hydrogen sulphide gases is derived from a coal gas purification process itself dependent on steam, failures of the single-stage Claus system are reduced to a minimum.

45 What we claim is:—

1. A continuous process for the recovery of sulphur from hydrogen sulphide-containing gas which process comprises burning the gas in a combustion chamber in the presence of a controlled amount of air, partially cooling the resulting gaseous mixture and passing it through a single catalytic reactor to bring about the conversion of hydrogen sulphide and sulphur dioxide to sulphur and thereafter condensing the sulphur, the catalytic reactor containing two or more layers of catalyst between which substantially sulphur-free process gas from the outlet of the sulphur condenser is recycled, to control the temperature of the gas leaving the reactor at a temperature above but approximating to the sulphur dewpoint.

2. A process as claimed in Claim 1 wherein the combustion gases are cooled to a temperature above the sulphur dewpoint so that substantially all the sulphur produced is condensed in a single condenser following the catalytic reactor.

3. A process as claimed in Claim 1 or Claim 2 wherein the temperature of the gases entering the catalytic reactor is in the range 300° to 400° C.

4. A process as claimed in any of the preceding claims wherein the substantially sulphur-free process gas is also recycled for addition to the gaseous combustion products of the original hydrogen sulphide-containing gases before they pass into the catalytic reactor.

5. A process as claimed in Claim 4 in which the conversion of hydrogen sulphide to sulphur is at least 96 per cent.

6. A process as claimed in any one of the preceding claims wherein that portion of the substantially sulphur-free process gas not recycled is mixed with air and the mixture heated and passed through a bed of catalyst for the oxidation of residual hydrogen sulphide to sulphur dioxide before discharge to the atmosphere.

7. A process as claimed in Claim 6 wherein the residual hydrogen sulphide is oxidised to sulphur dioxide in accordance with the process claimed in our co-pending Application No. 10746/54 (Serial No. 769,996).

8. A process as claimed in Claim 6 or Claim 7 which process is thermally self-supporting and wherein the mixture of air and substantially sulphur-free process gases is heated in a heat exchanger by the gases passing from the combustion chamber to the catalytic reactor.

9. A process as claimed in Claim 8 wherein the hot products of combustion of the original hydrogen sulphide-containing gas are partially cooled by admixture with a portion of the gases recycled from the sulphur condenser, the partially cooled mixture being then passed through the heat exchanger.

10. A process as claimed in any of Claims 6 to 9 wherein the hydrogen sulphide concentration in the gas mixture discharged to atmosphere does not exceed 1 part per million by volume.

11. A continuous, thermally self-supporting, process for the substantially complete oxidation of the hydrogen sulphide in gases containing not less than 50 per cent by volume of hydrogen sulphide to sulphur and sulphur dioxide, which process comprises burning the hydrogen sulphide-containing gas in a single combustion chamber, partially cooling the resulting gaseous mixture and passing it through a single catalytic reactor to bring about the

- conversion of hydrogen sulphide to sulphur and thereafter condensing the sulphur in a single condenser, the catalytic reactor containing two or more layers of catalyst
 5 between which substantially sulphur-free process gas from the outlet of the sulphur condenser is recycled to control the temperature of the gas leaving the reactor at a temperature above but approximating to the sulphur dewpoint, that portion of the substantially sulphur-free process gas not recycled being mixed with air and the mixture heated and passed through a bed of catalyst for the oxidation of residual
 10 hydrogen sulphide to sulphur dioxide before discharge to the atmosphere. 15
12. A process for the recovery of sulphur from a hydrogen sulphide-containing gas substantially as described in the specific example hereinbefore set forth with reference to the drawing accompanying the Provisional Specification. 20
13. Sulphur whenever recovered from a process as claimed in any one of the preceding claims. 25
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PROVISIONAL SPECIFICATION.

Improvements in or relating to the Recovery of Sulphur from Gases containing Hydrogen Sulphide.

- We, THE GAS COUNCIL, a British Body Corporate, of 1 Grosvenor Place, London, S.W.1, do hereby declare this invention to be described in the following statement:—
- 30 This invention is for improvements in or relating to the recovery of sulphur from gases and has particular reference to the recovery of sulphur from a hydrogen sulphide-containing gas.
- 35 In our co-pending Application No. 8316/52 (Serial No. 722,038) we have disclosed a two-stage process for the recovery of sulphur from hydrogen sulphide-containing gases which has advantages over the known Claus Kiln process. The disadvantages of the process of Application No. 8316/52 (Serial No. 722,038) are that it involves the provision of two or more second-stage reactors with changeover valves for periodic reversal in a system subject to corrosion and blockage, and that there is a tendency for loss of activity of the catalyst for the second stage, associated with a reduction of its surface area and an increase in its sulphate content.
- 45 These disadvantages would be minimised if the load on the second stage were reduced. We have therefore considered the means necessary to improve the degree of conversion of hydrogen sulphide to sulphur in the first catalytic stage which is a continuous process which, in effective practice, must always be conducted at temperatures above the dewpoint for sulphur. The equilibrium of sulphur can be more nearly complete the lower the temperature, and the reaction is strongly exothermic. The highest yields of sulphur from a continuously operated first-stage are therefore achieved by close temperature control by removal of the exothermic heat of reaction to permit operation at an outlet temperature nearly as low as the dewpoint for sulphur.
- We have now found that such close temperature control combined with much reduced dewpoint temperatures for sulphur and, in consequence, much increased sulphur yields may be effected by recirculation of gas from the outlet of the sulphur condenser to those zones where the exothermic reaction tends to raise the temperature too much; such addition of cool gases is termed "quench cooling."
- Recirculation may be compared with straightforward dilution as a means of lowering the dewpoint for sulphur. It has the disadvantage that one of the reaction products, viz., water vapour, is maintained at a high concentration. The advantage is that the volume of stack gases is not increased. At equal water vapour concentrations and sulphur dewpoints the minimum concentration of hydrogen sulphide and sulphur dioxide in the stack gas would be the same; high overall conversions to sulphur therefore depend on keeping the stack gas volume as low as possible. This result of the recirculation method far outweighs the disadvantages of high water-vapour concentration.
- The following table shows the effect of recirculation of gases from the outlet of the sulphur condenser:—
- | Recirculation. | Dewpoint for maximum yield of sulphur. | Maximum yield. |
|----------------|--|----------------|
| 0 vols. | 278° C. | 93.6% |
| 1 vols. | 250° C. | 94.9% |
| 2 vols. | 238° C. | 96.7% |
| 3 vols. | 228° C. | 97.2% |
| 5 vols. | 214° C. | 97.9% |
| 7 vols. | 208° C. | 98.3% |
| 11 vols. | 196° C. | 98.6% |
- These figures relate to a system in which the parent hydrogen sulphide gases con-

tained 68.5% of hydrogen sulphide by volume, wet basis, and in which the process gases at the outlet of the first catalytic stage contain 26% to 27% by volume of water vapour.

Recirculation involves the division of the gases leaving the sulphur condenser into waste gases and recirculation gases. The quantity of waste gases may be designated "one volume." In the table and throughout the Specification the quantities of recirculation gases have been expressed as multiples of the waste-gas volume.

In the table the yield of sulphur at the outlet of the first catalytic stage has been expressed as a percentage of sulphur content of the parent hydrogen sulphide gases.

For each extent of recirculation the yield is a maximum when the temperature at the outlet of the first catalytic stage is controlled closely above the sulphur dewpoint shown in the central column of the table.

The amount of recirculation permissible is limited to the exothermic heat to be removed:—

1. To cool the first stage reactor only, assuming an entry temperature of 350° C. to ensure destruction of any carbon oxysulphide present, not more than 1½ volumes may be recirculated. The minimum reaction temperature would be about 244° C. and the conversion could not exceed about 96%.

2. To cool the gases from the hydrogen sulphide combustion to reaction temperature and to cool the first-stage reactor, as much as 11 volumes could be re-circulated. The maximum conversion would be 98.6% and the lowest reaction temperature just below 200° C. There would be no indirect cooler such as a waste-heat boiler.

Recirculation tends to increase the size and capital cost of these units carrying the increased volume of gas; it must therefore be applied only to the extent that it gives a substantial improvement in the conversion or other marked advantages.

With 1½ volumes recirculated to control the first-stage reaction it should be possible to attain 95% conversion, whereas 90% would be the practicable limit in a single reactor without either recirculation or some more expensive method of cooling the gases uniformly. This form of recirculation control seems to give the most favourable conditions for a first stage reactor in a two stage system with sulphur condensation in the catalyst for the second stage.

The greatest advantage that can result from the recirculation method is the achievement of yields or percentage conversions, in the first catalytic stage, that are so high that no discontinuous second stage is required. Yields of about 97% are, in this country, sufficient if the hydrogen sulphide content of the waste gas is

destroyed, for example by oxidation to sulphur dioxide.

In our co-pending Application No. 8316,52 (Serial No. 722,038) we have disclosed the use of a nickel sulphate catalyst for the oxidation of hydrogen sulphide in the waste gases from Claus processes. We now find that the nickel sulphate method may be applied for the oxidation to sulphur dioxide of the concentrations of hydrogen sulphide present in waste gases from Claus processes, in which, for example, the yield of sulphur is 95%.

Conversions of about 97% in a continuous process, with an oxidation stage for the waste hydrogen sulphide, have been achieved in an existing plant for the recovery of sulphur from hydrogen sulphide-containing gases, comprising a hydrogen sulphide burner, waste-heat boiler, sulphur condenser, reheater first-stage reactor, second sulphur condenser, reheater, second-stage reactor, final sulphur condenser, addition of hot burner gases and excess air, final catalytic reactor for oxidation of waste hydrogen sulphide to sulphur dioxide, and tall stack.

By application of the recirculation method we have found a continuous process capable of achieving the same result with a single reactor and a single sulphur condenser; no waste heat boiler or any source of external heat being required.

According to the present invention there is provided a continuous process for the recovery of sulphur from a hydrogen sulphide-containing gas which process comprises burning the gas in a combustion chamber and passing the resulting gaseous mixture through a single catalytic reactor to convert the greater part of the hydrogen sulphide and sulphur dioxide to sulphur and thereafter condensing the sulphur the catalytic reactor containing two or more layers of catalyst between which sulphur-free process gas is recycled to control the temperature at the outlet of the reactor at a temperature substantially just above the sulphur dewpoint.

In a preferred form of the invention, sulphur-free process gas is also recycled for addition to the gases leaving the combustion chamber thereby effecting part of the duty of cooling the combustion gases and further lowering the dewpoint for sulphur at the outlet of the reactor.

Following is a description by way of example and with reference to the accompanying drawing of a method embodying the present invention.

In the drawing:

The single Figure is a flow sheet indicating the several steps in the treatment of a gaseous mixture containing hydrogen sulphide.

Referring to the drawing, air at a flow rate of about 13,400 cu. ft. per hour (cu. ft. are standard cu. ft. corrected to 60° F. saturated) is passed through a filter 11 and fed by means of a blower 12 to the burner of a combustion chamber 13 where it is burnt with about 5,850 cu. ft. per hour of gas having a composition by volume on the wet basis of

10	Hydrogen sulphide	68.5%
	Hydrogen cyanide	10.3%
	Carbon dioxide	13.9%
	Nitrogen	5.1%
	Water vapour	2.2%

15 The temperature in the combustion chamber is 1100° C.

The combustion gases are cooled to approximately 550° C. by the primary addition of quench gas at a temperature of 125° C. the volume of quench gas relative to that of waste gas being about 1½:1. The exact proportion of combustion gases to quench gas is controlled by means of an automatic valve operated by a temperature control unit 14 which controls the temperature of the gases entering the heat exchanger 15. The combustion gases are then further cooled in the heat exchanger 15 which also raises a mixture of waste gas and secondary air to the temperature required for the final oxidation of the hydrogen sulphide in the waste gas.

The combustion gases then pass to a catalytic reactor 16 containing three layers 17, 18 and 19 of activated alumina catalyst. The inlet temperature of the gases is 350° C. and is controlled by a temperature control unit 20 operating a valve in the secondary air conduit. Quench gas is added at 21 and 22 between the layers of catalyst, the volume of each addition of quench gas relative to that of waste gas being about 1½:1. The quench gas cools and dilutes the reaction gas, so that the outlet temperature is 222° C. The dewpoint for sulphur at the outlet of the reactor is about 214° C. The operation of the reactor with an outlet temperature close to the sulphur dewpoint is ensured by thermostatic control by control unit 23 of the combined volumes of the quench gases entering at 21 and 22.

The hydrogen sulphide/sulphur dioxide reaction on activated alumina is extremely fast at these temperatures, and a close approach to equilibrium is reached at high throughputs. Thus the total volume of catalyst may be as little as 10 cu. ft. for each ton per day of sulphur produced.

60 The gases leaving the reactor are next passed into an air cooled sulphur condenser 24 from the bottom of which liquid sulphur flows under gravity through a seal at the

rate 3.44 tons per day. The sulphur condenser is larger than that required in the absence of recirculation because the total cooling load is approximately doubled. However, it is still only a small atmospheric condenser.

The total volume of gas leaving the sulphur condenser is about 5½ volumes at a temperature of 125° C. of which 1 volume is passed to waste and about 4½ volumes are recirculated. The waste gas is mixed with about 19,000 cu. ft. per hour (1.1 volumes) of secondary air (from the filter 25 and blower 26) in the heat exchanger 15 and is passed into a catalyst vessel 27 containing about 20 cu. ft. of a catalyst of nickel sulphate supported on granules of activated alumina. The waste hydrogen sulphide is oxidised to sulphur dioxide on the nickel sulphate catalyst and the treated gases leave the vessel 27 at a temperature of 350° C. and then pass to the stack. The stack gases have the following characteristics:—

Standard volume	31,500 cu. ft. per hr.	
Wet volume	36,000 cu. ft. per hr.	
Dewpoint	52° C.	90
H ₂ S concentration		
by volume, wet basis	About 10 parts per million by volume.	
SO ₂ concentration		
by volume, wet basis	0.35%.	95
Total SO ₂ emission	500 lbs. per day.	

The recirculated gas for quench cooling is recycled by means of the blower 28 at 75,000 cu. ft. per hour at 125° C. saturated with sulphur vapour. The control of the primary air from blower 12 is maintained by an automatic analyser 29 for the hydrogen sulphide/sulphur dioxide ratio in the recycle gas.

The temperature control on the primary quench gas serves to protect the heat exchanger material from the corrosion which would occur much more rapidly at higher temperatures. The temperature is set at low as the heat balance of the plant permits.

The process described above, giving 97% conversion of hydrogen sulphide to sulphur is dependent on the primary utility service only, steam, for its continued operation. The steam is used in a single common prime mover for all the gas pumps and for protective heating of the plant at all positions vulnerable to sulphur solidification. Since the supply of hydrogen sulphide gases is derived from a coal gas purification process itself dependent on steam, failures of the single-stage Claus system are reduced to a minimum.

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